APPLIED SCIENCE

INCORPORATED WITH

TRANSACTIONS *of the* UNIVERSITY *of* TORONTO ENGINEERING SOCIETY

Vol. VIII - New Series

May, 1913 to April, 1914

PUBLISHED BY
THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY
ENGINEERING BUILDING
UNIVERSITY OF TORONTO, CANADA

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Old Series Vol. 26 TORONTO, MAR. 1914 New Series Vol. VIII. No. 11

*THE EXTENSION OF THE TORONTO WATERWORKS SYSTEM

By Professor Robert W. Angus

The water supply for the city of Toronto is obtained from Lake Ontario through two submerged intakes sunk on the lake bottom, from each of which a steel pipe runs to a well on Toronto Island. After passing through the filtration plant the water is conveyed across the Island in a steel pipe and under the Bay by means of a tunnel which terminates at the John Street pumping station. From this station the water for the lower part of the city is delivered directly into the mains, while that for the upper part of the city is delivered to the High Level Station, where it is repumped. The Rose Hill Reservoir serves as a storage for the lower district, the John Street pumps being directly connected to it.

Owing to the way in which the ground rises as one proceeds northward from the bay, the city has been divided into three districts (exclusive of the recently annexed North Toronto) for distribution purposes, the division lines between these districts being roughly by parallel lines along College Street and Dupont Street. These districts are called the low level, middle level, and high level respectively.

In 1911 there was only one intake from the Island into the lake, and through troubles of various kinds, this intake broke near the shore causing very great inconvenience and trouble. The City Council then appointed a commission of four engineers to report upon the whole matter of Toronto's water supply. This commission presented a report in February, 1912, covering a number of matters and recommending, amongst other things, a duplicate intake off the Island, which was later installed. and further, that an entirely new system with intake off Scarborough plateau be constructed.

After this commission's report was presented, several changes took place in the organization of the City Engineer's Department, and on the resignation of Mr. Rust, Mr. R. C. Harris was appointed Commissioner of Works in 1912. After a study of the Scarborough

* Read before the University of Toronto Engineering Society on March 9th, 1914.

scheme he felt that he could not be definitely committed to it, and as there was need of something being done as early as possible, he recommended that a money by-law relating to water supply be submitted to the ratepayers in the very widest terms, so that on January 1st, 1913, the citizens voted $6,677,000 "for additions and extensions to the water works pumping and distributing plant."

The money having been voted by the pepole, Mr. Harris felt that it would be safer to have the whole matter gone into by local men who have been in intimate touch with waterworks matters for some time. The writer was appointed as consulting engineer in the matter about the end of April last, and had with him Mr. James Barr, of the Works Department, a man of good ability and with an intimate knowledge of the city's plants.

Mr. Harris explained to us his ideas, and fearing lest I should be hampered in my line of work, I asked him certain definite questions, the answers to which made it perfectly clear to me that while he held certain views, he wished us to feel perfectly free to do just as we felt right in the matter of recommending the location of intake, size of plant, etc., etc., and it gives me the greatest pleasure here to record my appreciation of the freedom given me by Mr. Harris and the sympathy shown in all matters which I discussed with him. He has never made any effort to influence me in the slightest.

After a most careful study of the report of the commission of 1912, Mr. Barr and myself found it impossible to agree with their Scarborough scheme, for reasons set out elsewhere. We then worked out a second plan, which may be called the Victoria Park project, and which is described here in detail. The most of this description has been taken directly from the report of Commissioner Harris presented to the Council in December, 1913.

General Considerations

In selecting the point from which a water supply is to be drawn, a number of factors must be kept in mind, the most important of which are:—(1) The supply must be perfectly reliable, i. e., there must be no possibility of its failing under any circumstances. (2) The water must be comparatively pure. (3) The location must be chosen so as to admit of convenient distribution of the water throughout the city. These points are so self-evident that it is unnecessary to discuss them fully, but it must be borne in mind that some one of these may have to be selected as the controlling factor. Thus, there must always be a reliable supply, but so long as the water is quite safe and good, it may be necessary to allow the problem of distribution to be the determining factor in selecting the site. That is, if two or more sites furnish equally good water, that site is chosen which constitutes the best centre of distribution.

There are three possible places at which such installation may be located, viz.:—

1. At Toronto Island, adjacent to the present system. This site would naturally be suggested.

2. At some point west of the present works, e. g., west of Humber Bay.

3. At some point east of the Island, which would mean at least as far east as the Woodbine Racecourse.

The Island Location

Under many circumstances this would be the most natural to adopt, inasmuch as it is at the centre of the city, and contiguous to the section where most water is used. Study shows that it would not be satisfactory.

The bed of the lake slopes off gradually to a depth of 23 feet, at about 1,700 feet from shore, and then falls with a grade of over ten per cent., making the problem of construction of an intake difficult and uncertain.

It is essential to safety, that the extension be placed at some distance from the present system, to render it improbable that it may be affected at the same time, by any untoward happening.

As to purity: it is quite possible to treat the present supply so as to make it perfectly safe and very desirable. The location could not, therefore, be rejected on this score.

Anent the question of distribution. Toronto is increasing in size with very great rapidity. In the twenty years from 1890 to 1910, the population more than doubled, and the rate of growth since 1905 has been in greater ratio. This has naturally been accompanied by an increase in the extent of the city. At present, the distance from the easterly to the westerly boundaries is approximately ten miles, while from the bay front to the northerly limit of North Toronto approximates 6.4 miles.

The municipality will, doubtless, continue to expand to the north, east and west, with the probability that the greatest accretion of territory will be to the north.

As the breadth of the city increases, the problem of water distribution from a single source becomes more and more difficult, costly and unreliable, for if accident occur at the source of supply, famine is imminent, and the city is left entirely without reserve. Toronto has outgrown the stage where such a condition is permissible, and must follow the admittedly prudent policy of large lake cities similarly placed, and increase the number of intakes as the area of the city increases, in order to ensure uninterrupted supply, and furnish additional distribution centres.

Cleveland, Chicago and Milwaukee may be quoted in this connection. The first-mentioned city, with a population in 1912 of about 600,000, and a water consumption of 61 million Imperial gallons daily, is placing a second intake at the present time; the same being true of Milwaukee, a city of about the same size as Toronto, while in Chicago (population 2,259,000 in 1911), with an extreme length of twenty-seven miles, there are now six intakes, and two more are in contemplation. In Chicago there are land tunnels connecting the suction sides of various pumping stations, thus, from the distribution standpoint, practically increasing the number of sources of supply.

It must be conceded that Toronto must increase the number of intakes in proportion to the expansion of the city, and that the intake tunnels must supply pumping stations at convenient distribution centres, unless there be some overruling condition which prevents. At present, one new intake situated near one of the present city boundaries is imperative, and before the lapse of many years a second may be required near the other boundary.

The question then resolves itself, into whether the new intake and works shall be placed at the east or west side of the city.

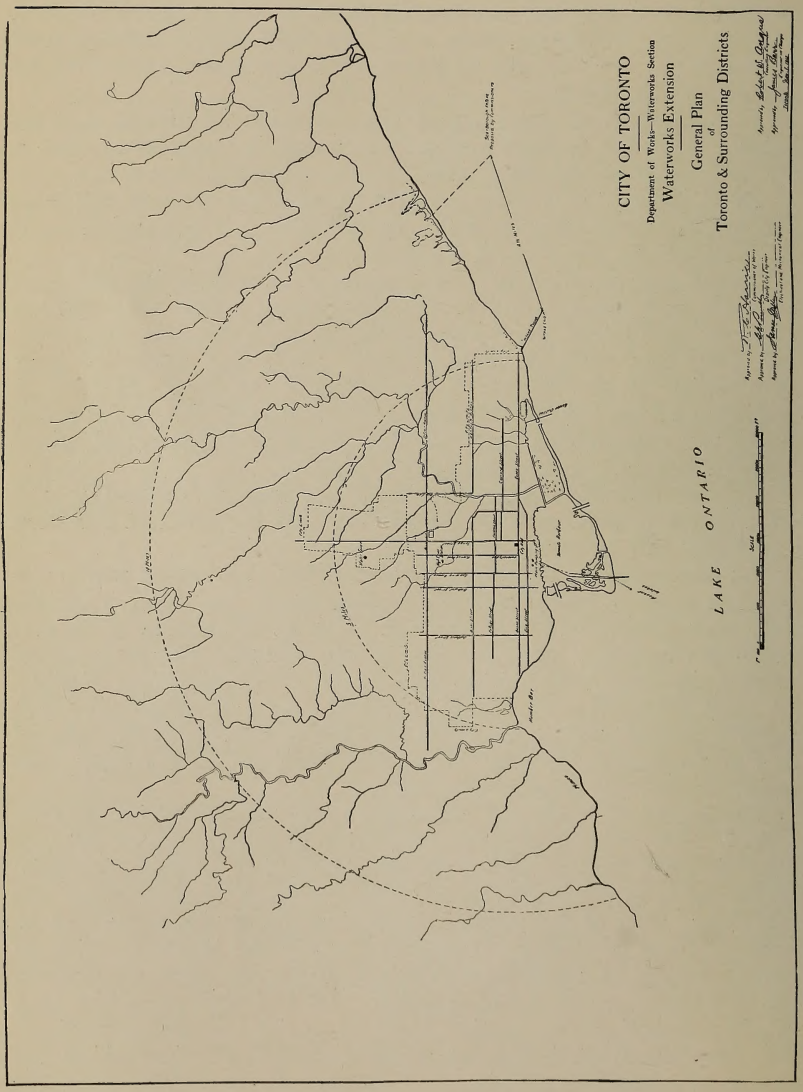

Fig. 1

The Westerly Location

An examination of the map, (see Drawing No. 1) shows that this location would necessarily lie to the west of Humber Bay, and it is probable that in the future an intake may have to be constructed at this point. Study of its possibilities will be made.

As to purity of supply: it is well known that there is at present pollution around Humber Bay and to the west, due to the condition of Humber River water, and other factors.

This cannot in any way be viewed as an insurmountable difficulty, inasmuch as proper treatment of the water would render it quite potable.

As to reliability of supply, there is little room for doubt that a safe intake could be constructed, although a survey would have to be made, along with lake borings, before a definite opinion could be offered.

There is, however, a very serious objection to this location in so far as distribution is concerned, as it lies considerably to the west of the present city boundary, and would thus require much large piping to conduct the water to the point where it would be first used.

The western location, therefore, would not be desirable.

The Easterly Location

There remains, then, only the location to the east of the Island. The westerly limit for such, would necessarily be at the Woodbine Racecourse, inasmuch as the Island ceases to exist at that point.

It is desirable to keep a safe distance from any large sewage discharge, therefore, having regard for the effluent from the Morley Avenue Sewage Disposal Plant, and the westerly trend of the lake currents, we are forced to the east. On the other hand, the further the distance to the east the more undesirable becomes the location from a distribution standpoint.

In order to get the best light possible on this extremely important phase of the question, the whole matter was examined with exceeding care, and studies of the shore line and contours were made, so as to form the best judgment.

An examination of the shore line, shows that while the ground is fairly level, and only about forty feet above the lake at Victoria Park, it rises at a rapid rate to the east, until reaching the very high ground forming the Scarborough Plateau. Should a point be chosen to the east of Victoria Park, therefore, the pumping station would have to be on made ground at the water's edge.

The foregoing, coupled with the results of preliminary surveys on land and lake, and the very desirable position of the park as a distributing centre, caused the Victoria Park site to be selected tentatively. A complete study has confirmed this selection. As this location differs very materially from that chosen by the Board of Commissioners of 1912, arguments are presented which not only show the desirability of the park location intrinsically, but prove

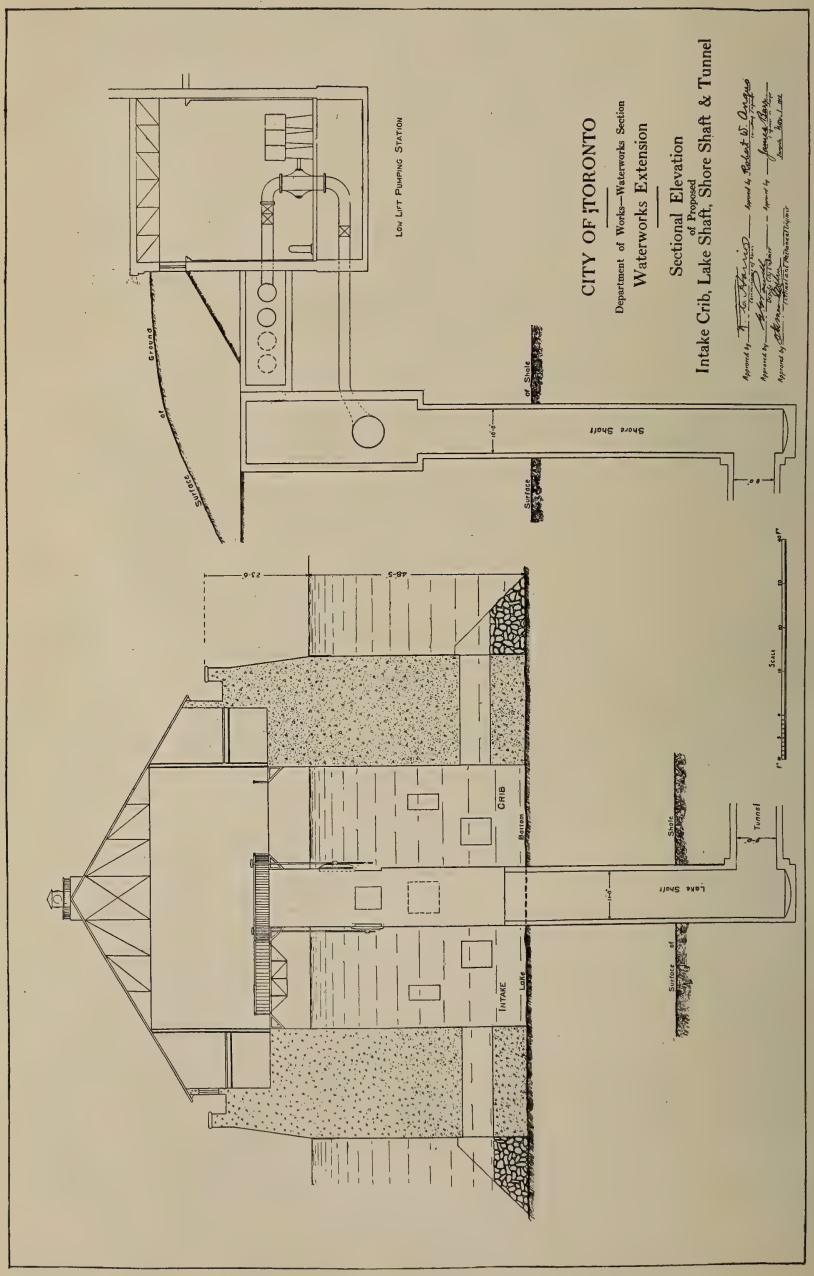
CITY OF TORONTO
Department of Works—Waterworks Section
Waterworks Extension
Sectional Elevation
of Proposed
Intake Crib, Lake Shaft, Shore Shaft & Tunnel
Low Lift Pumping Station
Shore Shaft
Lake Shaft
Tunnel
Crib
Intake
Lake
Surface
Bottom
Scale
Approved by
Approved by
Approved by

Fig. 2

that it has very decided advantages over the Commissioners' location, which is some five miles to the east of Victoria Park on the Scarborough Plateau.

Comparing these two last mentioned locations, from the essentials of a good source of supply, the matter of purity will be first dealt with.

There is a false sense of security in the idea, that by going, say, seven miles from the Morley Avenue Sewage Disposal Works, or any source of pollution, as the Commissioners proposed, pure potable water can be secured without after treatment. There can be no question, that in general, the further an intake is from any source of pollution, the purer will be the water, but this factor must only be allowed to exercise its proper weight, having regard for other influencing conditions, and the fact that any supply available for this city must be made safe by sewage purification, filtration and chlorination.

It is true that the rate of dilution of sewage in the lake increases as the distance from the outlet increases, so that up to a critical point there is a gain in increasing this distance, but beyond certain ranges the dilution is so great that a practical limit is set.

Again, it is well known that bodies of polluted water may move about the lake for miles without diffusion, and may in this way endanger, to some extent the supply to any intake within several miles of the city, if sewage purification and filtration be not adopted. In this connection it is helpful to refer to the report of Dr. G. G. Nasmith, director of laboratories, for Dr. C. J. Hastings, medical officer of health, presented on 5th October, 1911, at the request of the Council. Dr. Nasmith says:—

"At different times, sewage polluted water has been obtained at points as far apart as nine miles east of Toronto, five miles west of Toronto, and three miles beyond the Island."

"On July 26th, after a strong westerly gale, samples were obtained two miles east of Dutch Church at Scarborough, and one mile from the shore, which showed sewage contamination."

"This was the most graphic demonstration of what a heavy gale could do in driving sewage laden water long distances."

"From these analyses, and from the ocular demonstrations which we have had of these currents flowing in various directions with the wind, I am forced to the conclusion that currents of sewage polluted water may, at times, flow almost directly from the Eastern and Western Gaps to any intake that may be placed within a radius of several miles of the city. . ."

Continuing his report, Dr. Nasmith speaks of the pollution due to storm water and says:—

"From what I have seen this summer, and from the evidence I have laid before you, I have little doubt but that at times this polluted water will be carried to and beyond our present intake or any other intake that may be subsequently laid."

"I would sum up the report by saying that this investigation has proved, to my mind, namely, ... that we cannot,

with our sewage system as it is being constructed, hope to keep all untreated sewage out of the lake all the time, and that, therefore, ... we must, to obtain pure water, use both filtration and sterilization."

In view of these statements of Dr. Nasmith, it is evident that there is no hope of obtaining pure water at all times, at any reasonable distance from Toronto, and, therefore, the matter of primary purity must not be allowed to unduly affect the location of the intake, as the water must be treated in any event. The improvements in the treatment of water have been so great that water taken either off Victoria Park or Scarborough Plateau can be made perfectly safe and satisfactory for drinking purposes, and, indeed, at either place the raw water would be quite pure during the greater part of the year.

The report of the commission as relating to the purity feature, may be again quoted. In paragraph 2, page 21, they state that:—

"These investigations also lead to the conclusion that there is no locality along the lake front, from Mimico to Scarborough Heights, which has an assured purity, and, further than that, it is demonstrated that waters fifteen miles from shore are not free from contamination; hence there is no one locality within the range under consideration, at, or on, which you can locate a water intake with assurance that the water taken into it will be free from contamination; although at times healthful water could be secured at almost any chance location. And, therefore, we have no expectation of obtaining a water supply which must not be subjected to efficient artificial method of purification."

From the testimony of the commission as aforesaid, it is demonstrated that the Scarborough location offers no advantage from a purity standpoint, over the Victoria Park site.

From the point of purity, therefore, the water opposite Victoria Park, if taken at a distance of about one mile from shore and at a depth of about forty feet, would be perfectly satisfactory, and fully as desirable as that taken from further east. This location is two and one-half miles from the Morley Avenue outlet.

Another consideration which indicates the superiority of this location is the fact that, though the effluent from Morley Avenue Sewage Disposal Works is at present treated so as to largely deprive it of its contaminating influence, the city will, by the time the Victroia Park project could be completed, have in operation at Morley Avenue a system of purification which will render this effluent innocuous.

Dr. Nasmith, under instructions from Dr. Hastings, has for six months past been conducting experiments with a view to arriving at the best solution of this particular problem, and as soon as a conclusion is reached, a recommendation will be made to the Council to give effect thereto.

The question of turbidity is one of much importance. In order to ascertain the conditions at the selected point, observations have been taken, whenever there was any indication of disturbance of the

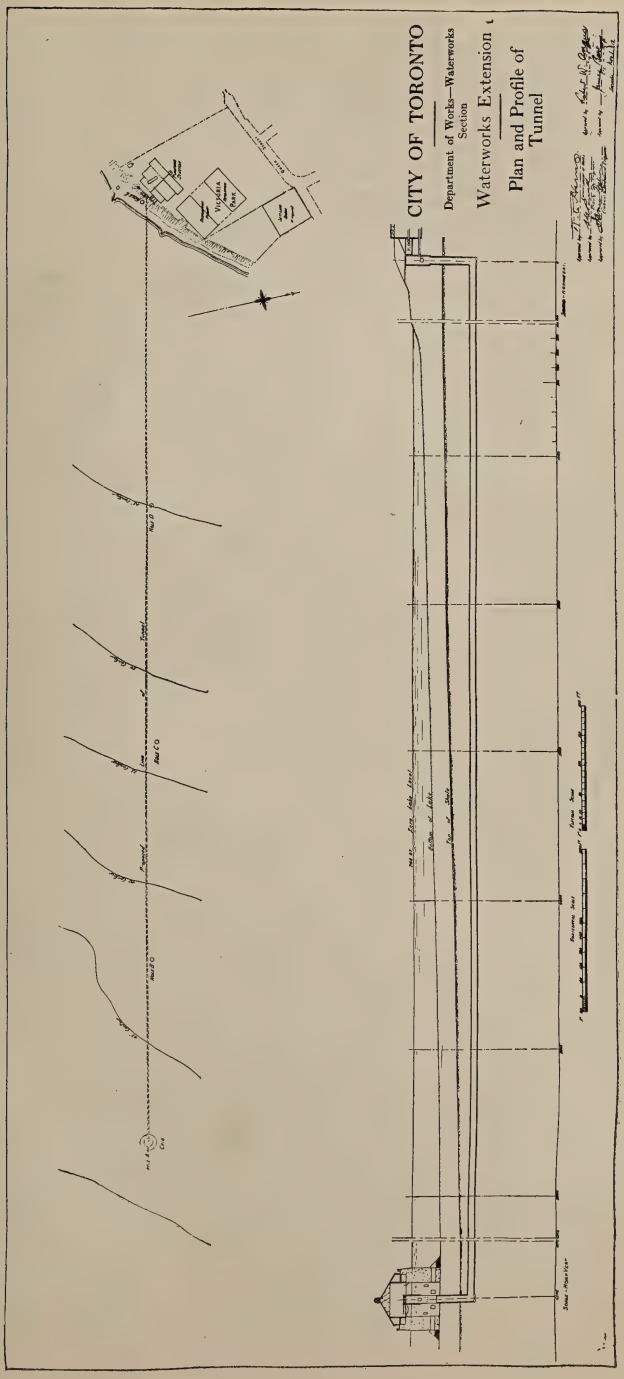
CITY OF TORONTO
Department of Works—Waterworks Section
Waterworks Extension
Plan and Profile of Tunnel

Fig. 3

clay, since the middle of September, but it has only been possible to obtain samples on three days, because of the fact that the turbidity has not extended out to the proposed site of the intake crib. In each case the observations were made after fairly heavy storms, although these were not of so long duration as would occur at other seasons of the year.

At the Victoria Park intake crib site, the turbidity at 20 feet and over, below the surface, did not exceed 2.0, while on one of these days the turbidity at the Island intake was 37; on another day it averaged 17, and on the third day it was 14. The proposed site is thus superior to the present intake locations in this respect.

Observations of temperature show that the water at the Park site will be slightly warmer than at the Island, the average difference being only 2° Fahr.

As to reliability of supply the Victoria Park site furnishes an almost ideal location. The accompanying tunnel plan shows a series of soundings taken at this point, and indicates a gently sloping lake bottom, for a distance out of two miles and over, on the line of the tunnel. At about 2,100 feet from shore, the depth of water is 25 feet, at 3,700 feet it is about 33 feet, and at 6,400 feet out it is nearly 49 feet. The average slope of the lake bed is thus less than one per cent., furnishing a spot sufficiently level to place an intake at any desired point. (All depths are referred to Zero lake level).

The results of a series of borings made at this location, indicate that at about 6,400 feet off Victoria Park, in a depth of 49 feet of water, shale was struck at 82 feet depth. At about 5,200 feet from shore, in a depth of 42 feet of water, shale was struck at a depth of 72 feet, and at corresponding depths at other locations, the depth of the shale at the shore being 50 feet. These borings all show that it is quite possible to tunnel in shale, to an intake placed nearly one mile from shore, and in a depth of approximately 49 feet of water, driving the tunnel in good shale, without going to a depth which would preclude compressed air working should it prove necessary.

The drawing showing the section of the tunnel also indicates the profile of the lake bottom, and the line of the shale as found from the actual borings. (Drawing No. 3).

It is, therefore, quite possible to construct at this site a tunnel and intake, which will, without doubt, ensure safety and reliability.

Another advantage of this position is its convenience as a distributing point to the present city system. The city is growing in all directions with considerable rapidity, and hence what now constitute the city limits, may in a few years be well inside. Victoria Park, therefore, will probably, in a few years, be surrounded by a populous district.

A station at this point will be in admirable position for connection to the present system. It is not too far removed from the sections where most of the water is used, and any main laid from the station will be used for distribution from the point where it leaves the park. This is discussed fully later in this report.

The Victoria Park location has thus (aside from the weaknesses of the Scarborough Scheme) a very decided advantage over that at Scarborough Plateau, advised by the commissioners of 1912. It is nearer the city, and is, therefore, much more convenient as a distributing point. It is also a perfectly practical and reliable location, and gives water quite as safe for drinking purposes as that which would be obtained at the Scarborough location.

In connection with the present project, additional reservoir capacity is not provided, as it is deemed unnecessary. This will be discussed later.

The Proposed Works at Victoria Park

General

In general, it is proposed to build an intake crib off Victoria Park, about one mile (5,100 feet) from shore, in 49 feet of water. The crib will be approximately 110 feet in diameter, constructed of steel and concrete, and surmounted by a house, the main part of the crib rising 19½ feet above the lake. The house will carry a permanent light and the requisite fog signal apparatus, and include living rooms for men. The crib will contain the necessary ports for the admission of water.

The inside of a crib will contain a vertical steel shaft, lined with cement or brickwork, running down to a proper depth below lake level, so as to connect with the tunnel 6,380 feet long, running horizontally to the shore at Victoria Park. The internal diameter of the shaft will be 11 feet, that of the tunnel 9 feet, the latter to have its invert 105 feet below mean lake level. At the shore, there will be a vertical shaft 10 feet diameter, rising above the normal lake level at this point. From the vertical shore shaft there will be two horizontal 7-foot tunnels, one on each side and parallel with the shore. One of these tunnels will supply the suction side of the pumps in the station to be erected, the other will act as a reserve to be used in case the size of the station is increased later.

The pumping station will be located in Victoria Park, which, with a piece of land to the east, is of sufficient size to contain a station and filtration plant of a capacity of 120 million imperial gallons per 24 hours, should such capacity ever be required. There will still be room for a fair-sized park, and the grounds lend themselves admirably to a very fine layout, so that the new plant and park may be made exceedingly attractive. The land will be graded and planted, a protecting breakwater erected, and the banks terraced.

The new works will in no way interfere with free passage and use of the beach, this being left as clear as at present, and the use of the breakwater will prevent the water encroaching further upon the property.

The pumping station will have a capacity of 60 million Imperial gallons per 24 hours, but is being so designed that this may very easily be increased to 120 millions gallons if desired, without lost expenditure, save that occasioned by the removal of a single end

wall. Since the water will have to be filtered, the station must be divided into two parts, viz., low-lift and high lift, the former taking the water from the tunnel shaft and delivering directly to the filters, while the latter will deliver the filtered water direct to the city mains. Each part will have a capacity of 60 million Imperial gallons per 24 hours. The low lift pumps will work against a head of approximately 75 feet, while the approximate head on three of the high lift pumps will be 220 feet, or 95 pounds per square inch, and that on the fourth pump about 315 feet or 137 pounds per square inch. The exact pressures against which the low-lift pumps will have to work, cannot be determined until the make of filters is known.

The mechanical type of filter is recommended, and in connection with this it is proposed to instal a reservoir with a capacity of two-and-a-half million Imperial gallons, and to provide space for a settling basin should the make of filter require it.

From the station, four 36 inch pipes will deliver water to four new 42 inch mains which join the present distribution system, as outlined later in this report.

This plan contemplates:

1. A system which will supply an additional quantity of water equal to that now being used during maximum draft, thus practically duplicating the present plant.

Therefore, in the event of accident at any time to the sewage purification plant, or either filtration or pumping plants, the use of either plant could be discontinued, and the safety of the supply still maintained. By reason of the proposed plant being a duplicate in capacity of the existing plant, with provision for future increase, the continuity of the supply is assured.

2. A system which will operate in exact harmony with the existing plant, thus enabling both to work in conjunction.

3. An arrangement which can be doubled in capacity without doing unnecessary work.

4. A supply which is unfailing, in so far as human agency can make it. It will not be deleteriously affected by storms, ice, shifting sand, etc.

5. A supply of water, which is as pure as it is possible to obtain in the vicinity of Toronto, and which after treatment will be perfectly safe and satisfactory.

6. An improved service throughout the entire city.

7. An attractive park on the waterfront.

Details of Waterworks Extension

The final details of the various parts have not yet been completely planned, pending approval of the project.

Intake Crib

The intake crib is, in a sense, the most important, and, in some ways, the most difficult part of the work. On account of the nature of the elements to which it is exposed, the design should be worked out from the experience of others. Cribs have been constructed

in the lakes by various other cities; at Buffalo the crib is 110 feet diameter in 18 feet of water; the Cleveland crib is nearly five miles from shore in 49 feet of water, and is 100 feet in diameter. Chicago has six cribs of varied construction, some with surrounding breakwaters, and the latest designed without. Of the latter, the Harrison crib is 112 feet diameter and is in 34 feet of water, while the new Dunne crib is 111 feet diameter, and in 33 feet of water. The Milwaukee crib is under 60 feet diameter, and is in 25 feet of water, but from a study of conditions, it appears to be inadvisable to adopt so small a size.

From a study of the experience of these cities, it is concluded that the Toronto crib should be 110 feet diameter.

The depth of water in which the crib can be set depends upon the method of placing it, and the forces to which it will therefore be subjected. This crib, made of a steel shell, will be constructed in the Harbor and floated to the desired location and sunk. On account of the depth of water in the Bay, the shell could not be floated to a greater depth than 17 feet. It is clear that the success of such an undertaking will depend, to a very large extent, upon the relative amounts of the shell above and below the water surface when floating, and as the depth below is, in this case small, the total height of the structure is limited. So far as known, no city in America has installed a crib under such conditions as those existing at Toronto, in water deeper than 50 feet, the Cleveland intake being the deepest.

Since the cost of this part of the work will be great, and hence any successful experiment would be very serious, it is not advisable to attempt anything that has not been done successfully elsewhere, so that the depth of water in which this crib will be placed is 49 feet. The water entering such a crib will be quite as good for drinking purposes as if taken at much greater depth.

The intake crib will consist of two concentric steel cylinders, set on end and firmly braced together, so as to be rigid and stiff, the outer cylinder being 110 feet diameter, and the inner 60 feet diameter. Plates set radially between these shells will divide the annular space into compartments, which will be constructed with bottoms so as to make them watertight. The compartments will then be sufficiently filled with concrete to make the draft of the structure seventeen feet, after which it will be towed into the desired position and sunk, the lake bottom having been previously levelled and otherwise prepared for its support. After sinking, the annular space will be filled with concrete, and the structure built up above the water to provide living quarters for men, with lights and signals for mariners.

Properly constructed ports in the crib will admit water to the inner 60 foot well; these ports will be controlled by gates which may be closed at pleasure, but the water will never be pumped from the inside of this well. An arrangement has been provided, however, so that it will be quite possible at any time to pump all of the water out of the tunnel for cleaning and other purposes, should this be desired.

(*To be concluded next issue.*)

THE KINEMATOGRAPH AT THE UNIVERSITY OF TORONTO

By G. R. Anderson,
Associate Professor of Physics.

The evening of February 6th, witnessed the first public use of the new moving picture installation at the University of Toronto. The occasion was that of a lecture by F. N. Speller, B.A.Sc., '93, Engineer of the National Tube Company, of Pittsburg, on the manufacture of steel tubes and pipes, delivered to the Engineering Society of the University and the Central Railway and Engineering Club of Toronto. The exhibition included all phases of the work, from the mining of the ore to the testing of the finished product, and was unique from an educational point of view, and thoroughly appreciated by the large audience present.

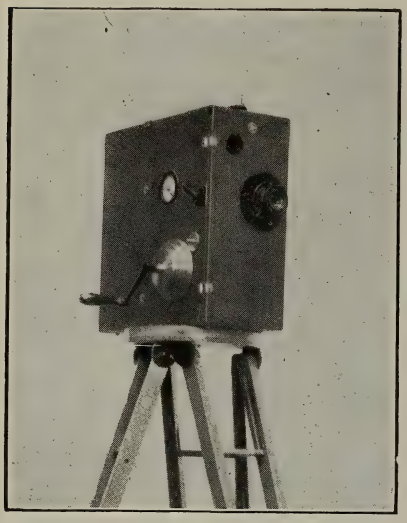

Fig. 1

In view of the widespread interest evinced in this method of illustration, a general description of the various parts of the installation may be of interest to readers of Applied Science.

The camera for the taking of films is illustrated in Fig. 1. It consists of a leather-covered body containing the usual film-boxes, each capable of holding 60 metres of film. The lens is an anastigmat of focal length (2 in.) and having an aperture of 3.5, thus permitting of exceedingly rapid exposures. The finder is large, and so placed that the field may be observed throughout the exposure. The film is ordinarily driven by a crank, but provision is also made for motor driving when desirable, as will be seen by the triple-step pulley, shown in the illustration. An indicating dial on the side of the camera shows the amount of film being used.

The equipment also includes the apparatus necessary for the animated photography of microscopic objects, such as bacteria, for which purpose the parts are arranged as shown in Fig. 2. The stand is entirely of metal, and sufficiently heavy to be perfectly rigid. The camera is attached to a pair of vertical rods in such a way that by loosening the lever L it may be instantly swung to one side, leaving the microscope in position for eye observation, and as quickly returned to place. The lens of the camera is removed and connection with the microscope established by means of a small leather bellows, while an adjustable lens inserted in the side of the camera permits the observer to watch the microscopic field at the same time that the photographs are being taken. The film in the case of microscopic work is

preferably driven by a motor operating against a worm gear, whence the motion is transferred by a belt to the camera. The motor is controlled by a foot-switch, so that the operator has both hands free to take care of the adjustments of the microscope and lamp. The light for the illumination of the microscopic field is furnished by a small arc lamp, the light from which passes through a condenser and a liquid cell to absorb the heat and, if necessary, the violet and ultra-violet rays. All these accessories move on a planed optical bed and are readily adjustable to suit requirements.

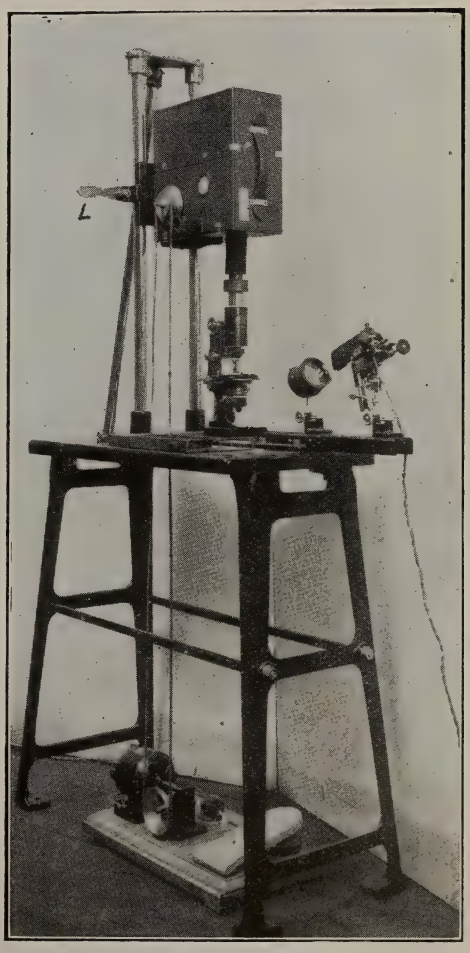

Fig. 2

The microscope is a Zeiss of the large barrel type, specially designed for photomicrography. It has a photomicrographic stage, adjustable by rack and pinion in two directions, its position being indicated by verniers reading to 1-10 mm., and furnished with an achromatic substage condenser, which can be instantly swung out if not required. The optical equipment consists of 4 apochromatic objectives and 6 compensating oculars, giving magnifications ranging from 31 to 2,250. Provision is also made for using polarized light if required.

The projector (Fig. 3) for exhibiting the finished films is of particularly substantial construction to insure steadiness and rigidity. The stand is of metal, and has a tilting top with a range of about 17°, permitting of both elevation and depression. The lamp-house is constructed of sheet iron, lined with asbestos, ventilated by means of a rising roof provided with a wire guard and closed at the rear by an asbestos curtain. The lamp is of the right angle type, provided with adjustments for tilting, raising and side-swinging the arc. The condenser is open-mouthed, of hard water white glass, and can be instantly lifted out of its bearings. The film fire-guard, G, is a dis-

tinctive feature of this projector. It is of two-ply steel, enclosing an interlining of asbestos, and extends from the upper magazine wall above the film exit to the base, so that there is no possibility of the film coming into contact with the lamp. The magazines are large and of very solid construction, consisting of spun steel without joints and lined with asbestos; the doors are securely locked, so that

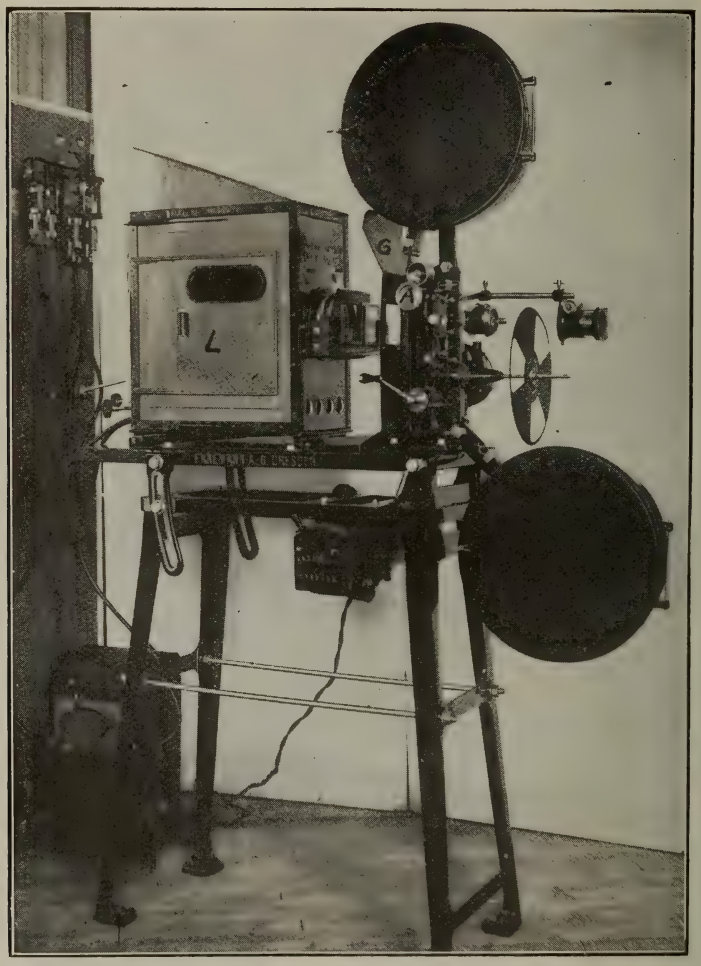

Fig. 3.

it is not possible for them to become unfastened accidentally. The film emerges from the upper magazine through a film-way of metal, closed by a clasp, and which is so narrow that in the event of the film taking fire the flame cannot pass up through this throat and set fire to the reel; the same construction is, of course, followed at the lower

magazine. The winding of the film on to the lower spool is effected by a metal driving-rod geared to the main shaft. This is much more reliable in its action than the usual belt drive. Fig. 4 shows the left side of the machine with the cover of the Geneva movement removed. The special features of this vital part of the mechanism are the extra large Maltese Cross and the roller bearing for it to oper-

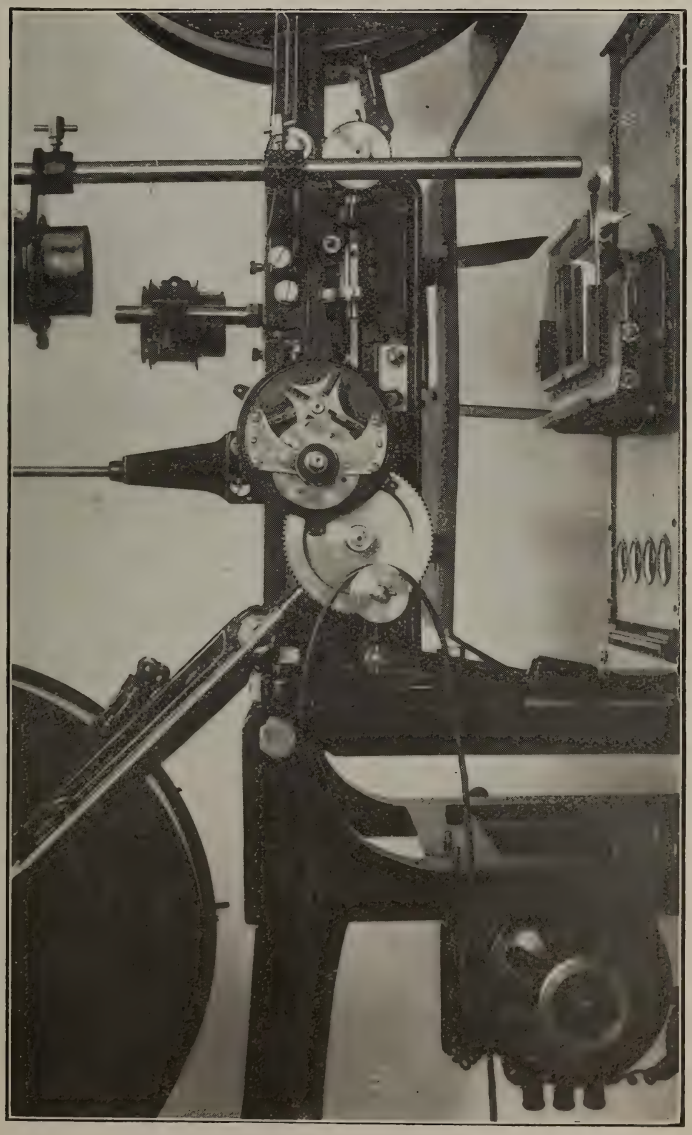

Fig. 4.

ate on (ordinarily this roller is merely a pin); this eliminates friction, noise and wear of the parts; further, the whole movement is enclosed in an oil bath.

The machine is driven by a motor bolted to the framework and provided with a speed regulator, so that absolute steadiness of the film is secured over a wide range of speeds. The lamp-house slides on two planed rails, so that it can instantly be pushed over to the end for the purpose of showing ordinary slides. These are inserted in a double carrier attached to the frame on which the condenser rests, and one slide may always be left in place while the film is being shown. There are two projection lenses of large aperture and flat field, one for the projection of the film and the other for the slides, the focal length of the former being 5 inches and of the latter 15 inches, so that the images from film and slide are of equal size. The adjustment of the mask to fit the film is accomplished by a rack and pinion movement operated by a large milled head, shown at A, Fig. 3. This permits of the film being correctly placed without interfering with the position of the projecting lens or the mask, an exceedingly convenient arrangement in practice. The workmanship throughout the entire installation is of excellent quality, the gears are carefully cut, and the machine runs lightly and steadily with a minimum of noise.

EDUCATIONAL ESSENTIALS FOR BRIDGE ENGINEERS

By Henry Grattan Tyrrell,
Consulting Engineer, Evanston, Ill.

My attention has lately been called to a serious lack in engineering education, a description of which will be especially interesting to bridge engineers. In order to explain the matter I will relate the incidents without giving names.

I was recently employed by one of the large railroad systems to make special investigations and reports on bridges scattered over 700 to 800 miles of railway. The company was equipped with a full engineering corps including separate departments for bridges and buildings with a drafting force of twenty to thirty men under the direction of two men with titles of engineer of bridges and engineer of buildings respectively.

Double tracking and bridge renewals were being considered, and the railroad company was in doubt as to the proper type and length of bridges to specify. Guesses had been made by the man who was then chief engineer of the road, as well as by his predecessor, and division engineers had also given their views as to the need of bridges in certain places and their required length. As the various reports and opinions of the two chief engineers with the bridge engineers and their associates differed by 400 to 500 per cent., it was decided to secure a report from a specialist. In one case where the road crossed the same stream three times under similar conditions, the longest bridge was three times longer than the shortest one, and for no other reason than difference of opinion,

as the shorter structure served every useful purpose quite as well as the longer one.

On visiting the bridge department of the road, the writer found the bridge engineer in charge fully qualified to make detail drawings of bridges when the type and general dimensions had been fully specified, but quite unable to determine the economic type or its proper length. Custom had governed the choice in these matters, and as previously stated, the custom of different men differed by 400 or 500 per cent. The absurdity of the situation then loomed up strongly when it appeared that steel bridges had been installed where earth embankments should have been, and an amusing feature of the situation was, that after choosing improper types and general proportions costing three or four times more than needed, the engineering department was then calculating stresses to decimals and endeavoring to reduce the cost by saving in details.

The conclusion at once became evident that while engineering schools were turning out men who could calculate stresses and detail structures with exactitude, there was need for a wider knowledge of the primary essentials.

One of the most important duties of a bridge engineer is the selection of economic types and the determination of general dimensions and design, but too often this is fixed by custom, guess or judgment. The cost of a bridge is affected most of all by its form and proportions, and sizes which are too large and excessive are often specified when smaller ones with embankments at the ends would leave ample space for the highest floods. The difference in cost between a 500-foot and a 300-foot bridge might be $15,000 to $20,000, and if the greater length is specified where the shorter one would do, the figures given represent the loss which might have been saved by greater engineering knowledge. Whereas, after specifying a 500-foot bridge, the greatest saving which an expert detailer could make would not exceed $4,000 to $5,000, or only one quarter of the saving which would result from careful and competent preliminary investigations.

A. R. Raymer, '84, assistant chief engineer of the Pittsburgh and Lake Erie Railway, was recently elected president of the Engineers' Society of Western Pennsylvania, with head quarters at Pittsburg. This is a large organization, representing the engineering interests in Pittsburgh and environs.

F. T. Nichol, B.A.Sc., '10, is Western representative for Clarence W. Noble, contracting structural engineer, with his head quarters at 905 Electric Railway Chambers, Winnipeg, Man.

A. D. Macdonald, B.A.Sc., '10, is assistant superintendent with the Penn-Canadian Mines, Cobalt.

L. R. Thomson, '05-'07, is with the Dominion Bridge Co., Montreal, Que.

W. K. Thomson, B.A.Sc., '13, is with the Topographical Survey Branch, Department of Interior, Ottawa.

THE TWELFTH ANNUAL BANQUET OF THE UNIVERSITY OF TORONTO CLUB OF NEW YORK

The banquet of the above club took place in the Plaza on Tuesday, March 3rd, and turned out to be the most successful in the history of the Club.

The date of the banquet had been changed from November to December and finally to March 3rd, in the hope of having, for the guest of honor, President Falconer, who was, unfortunately, at the last moment, unable to take the journey on account of illness. Dean Galbraith was, therefore, the sole but able representative of our Alma Mater, and even he had no idea whether or not he would arrive in New York without being fifteen hours or more late on account of the blizzard. So, when he left Toronto for New York, it seemed to him like starting on a South Pole expedition, but "all's well that ends well," and Dr. Galbraith arrived at the proper time. Feeling that the responsibilities of the University rested upon his shoulders, he delighted the members and distinguished guests with the best speech of his life—an enviable record.

The second speech of the evening was by the celebrated sculptor, Mr. Gutzon Borglum, the designer of that incomparable statue of Lincoln in Chicago. He is always a powerful speaker, and naturally at home on the subject of art.

Mr. Santamarina, an engineer and editor from the Argentine Republic, followed, with a clear cut and emphatic talk on the relations of North and South America, taking a point of view not at all flattering to the Monroe Doctrine. Although he did not hesitate to speak very plainly—his Spanish politeness prevented his offending anyone—when he had finished it looked as if he had all the argument on his side. However, the fourth speaker, Mr. W. Tyrie Stevens, president of the Circumnavigators' Club, a young Canadian who, in addition to having been around the world, knows South America very well—when called upon to respond to "Our Sister Societies," took occasion to differ very decidedly with the views of Mr. Santamarina. Mr. Stevens asserted that, but for the Monroe Doctrine, there would be no South American republics, as all would long since have been seized by European powers.

Thomas H. Alison, S.P.S. '92, president of the University of Toronto Club of New York, made an excellent toastmaster, and he had the representatives of the sister societies of Queens and McGill, as well as Mr. Muirhead from the University of Glasgow, and Mr. W. Tyrie Stevens, president of the Circumnavigators' Club, at the table with him and the guests of honor.

The following past presidents attended:—Dr. Walter F. Chappell, Dr. T. Kennard Thompson, Mr. Robert Henderson, Mr. E. W. Stern, Dr. E. R. L. Gould, Dr. Chas. Graef—given in the order of their terms of office—showing the way the past presidents keep up their interest in the Club.

The first president and father of the Club, is George H. Ling, Ph.D., who is now in charge of the mathematical department of the University of Saskatchewan in Saskatoon, and could, therefore, hardly be expected to attend.

THE WAIL OF THE SURVEYOR

Did you ever hold a survey job, with transit, rod or chain?
You never have? Well I did once, but never will again.
I wasn't at it fifteen years, nor ten, nor eight, nor three,
I held a rod for just three months; that was enough for me.

What was the matter with my job? Oh, nothing much I guess,
'Twas just as good or better, perhaps, than any of the rest;
I didn't have to work too hard, I got enough to eat,
That is, I nearly always did: my boss could not be beat.

I guess you're wondering what was wrong, and what I'm kicking at.
Well, I don't like those survey jobs and never will, that's flat.
Construction work may be all right, that kind I've never done,
Location in the bloomin' bush is anything but fun.

Do you know what a tump-line is, or what you use it for?
You don't, well now, here's hopin' I don't use one any more.
I don't mind working hard all day, or even half the night,
But when it comes to being a horse, then I sure want to fight.

A tump-line is an instrument, not fit for man or mule,
A kind of harness once thought out by some darned meddling fool,
Who thought the Good Lord got things wrong when he made human freight,
For this darned yap with his fool game keeps us from standing straight.

If ever I meet that guy, in heaven or in hell,
'Bout all that's left when I get through with him will be a smell.
What's that? I haven't told you yet what this here tump-line's for,
That's right, but when I think of it, it always makes me sore.

I don't know how to tell you how they work the crazy thing,
You fasten it around your pack and give your pack a fling
Upon your back, and then you put the strap across your head
And bend your neck, and walk, and walk, until you're almost dead.

I guess that it's the only way for moving in the bush,
But I'd prefer to walk behind a cart all day and push,
Altho' I wouldn't make much more than half a mile a day,
For bush trails ain't macadam roads, as any guy will say.

And when you strike a muskeg—say—that's where your fun begins,
You don't know what a muskeg is? It's a punishment for sins.
A muskeg's something like a swamp, and then again it ain't,
It's worse than any swamp that any artist born can paint.

Can you imagine soaking moss about fifteen feet thick,
So deep you can't reach nothing hard by prodding with a stick,
And where you sink above your knees, at every single step,
That's where you learn to curse things blue and lose your golden rep.

A muskeg's sure an awful place to have to pack across,
For of all rotten footings nothing touches thick wet moss,
You slop along and slide and sweat and curse and swear,
And wish to God that you were any other place but there.

Perhaps you think that packing in a muskeg is the worst
A fellow has to stand for in this land of the accursed,
But don't you ever think it, packing's just like eating pies
Compared with something else you meet, and that's the cursed flies.

Now unless you've felt them, there is no use trying to tell,
There's just one word describes the "flies" and that one word is "Hell."
If Lucifer, to torture souls, is ever in a fix,
He'll simply have to take ten billion flies across the river Styx.

Mosquitoes, though they're bad enough, are gentlemenly flies,
When one gets down inside your shirt, he just curls up and dies.
But not for Mr. Black Fly; He don't care for etiquette,
When he gets down inside your shirt he doesn't quit you bet.

And if a skeeter bites you, he cleans up when he's through,
And takes the blood along with him like any gent would do;
But Mr. Black Fly bites a chunk of flesh clean off your face
And leaves a little stream of blood to mark the bloomin' place.

But then the black fly's better than the skeeter in one way,
He quits at night and only works while you work, during the day.
The skeeter never quits at all, for sleep he doesn't care,
And though you can't see him at night, you bet you know he's there.

He buzzes all around your head, and though his noise is bad,
You know what's doing when he quits, so buzzin' makes you glad,
For when a skeeter doesn't hum as loud as he can cry,
He's either full already or, he's stinging some poor guy.

And in the morning early, you begin to look around
There in the corners of your tent are surely to be found
Mosquitoes, full of bright red blood, and then you start to think
That it was you or else your pal provided them with drink.

Now, I could tell you folks a lot about the grub we got,
How everything was served lukewarm, or else a lot too hot;
Why, I could grouch a hundred years about that survey game
And then I guess there'd still be kicks I hadn't called by name.

But I'll quit this line of talk because there always is,
And always will be guys who really like this survey biz.
But not for mine, that survey work with me don't make a hit,
The only part I liked was when they told me I could quit.

Geo. J. McLaughlin, in "Outdoor Canada."

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published every month in the year by the University of Toronto Engineering Society

SUBSCRIPTION RATES

Per year, in advance $2.00
Single copies 20

Advertising rates on application

Address all communications:

Applied Science,
Engineering Bldg., University of Toronto,
Toronto, Ont.

EDITORIAL

ORGANIZATION OF CLASS '05

Members of the graduating class of 1905 are contemplating a reunion in 1915 to celebrate the 10th anniversary of their entrance into professional work. The exact nature of the reunion has not been decided upon as yet and another meeting will be held in the early fall to arrange details. All members of the class will be notified shortly concerning it. Those present at the meeting which has already been held were. W. Barber, N. L. R. Crosby, C. S. L. Hertzberg, A. Latornell, T. R. Loudon, F. A. McGivern, L. W. Morden, G. W. Rayner, C. H. Shirriff, W. M. Treadgold, H. L. Wagner and J. N. Wilson.

SCHOOL DINNER AT OTTAWA

The "School" graduates at Ottawa are holding a dinner at the "Chateau Laurier" on Saturday evening, at which Dean Galbraith will be the guest of honor. A contingent of "School" men from Toronto are attending. A number from Montreal and other points within a reasonable distance of Ottawa will attend. Full particulars will appear in the April issue of Applied Science.

"HINTS TO THOSE APPLYING FOR EMPLOYMENT"

Do you want employment? If so, you should exercise every care and diplomacy in submitting your application. At this season of the year when engineering activities are assuming renewed energy, and a large number of our men will be assuming new duties, perhaps a few hints with respect to making application for a position will be of interest, especially to the undergraduates.

The writing of a letter, asking for employment, seems but a small matter, but the outcome of the letter may mean much to the applicant. On the one hand, it may mean the opening up of a bright and successful business future, while on the other hand it may mean the necessity of applying elsewhere for a less lucrative position.

Employers study the applicant before accepting him, not always through personal acquaintance, but through whatever medium presents itself, the only medium often being the written application. The man who is careless in making application for a position can scarcely hope to favorably impress his prospective employer with respect to the care which he would likely exercise in carrying out the duties connected with the position. Some attribute the result of applications to what is commonly termed "luck," but more often the applicant himself, probably unwittingly, plays the deciding role.

The following letter from a graduate to one of the Professors at the "School" will no doubt offer some suggestions of interest to our readers.

Dear Sir:

I have an application from one of your men to start with us in a similar way to what C..... did, and his letter is such a bad example of an application that I feel moved to make some suggestions. I thought perhaps you might like to give your class a few pointers on how to apply for a situation.

The application I received was written on a half sheet of very cheap note paper, and I would suggest a sheet of letter paper or a full sheet of good note paper.

There is no margin to the letter and I think they generally look better with a margin.

He gives no information about himself except his name and that he is graduating this Spring, but asks us to send him some information. I think we would like to know whether he is studying mechanical or electrical engineering, his standing in class, if not too

bad, and any special subjects he has studied in preparing a thesis or anything of that kind. About himself personally, I think we would be interested to know where he comes from, his nationality, his age, and perhaps even his height and weight might be of interest. His previous experience would be a help to us in knowing how to place him. A..... I think, is a more useful man to us because he has run a rock drill a little while, has bossed a gang of laborers and has been on a canoe trip in the wilderness. If a fellow has worked on his father's farm, clerked in a village store or made a record selling stereopticon views in the holidays, he may be a better man for us.

Don't take these few suggestions too seriously or think that I am trying to find fault, but I thought a few hints along these lines might be of help.

THE ENGINEERING SOCIETY ELECTIONS

March 13th, 1914

Owing to the tendency toward the formation of clubs throughout the "School" for the purpose of increasing the value of their University course, it has been felt for some time that the Engineering Society was not supplying the members with what they really wanted and needed. Several clubs had been formed throughout the various departments for the purpose of arranging suitable excursions and encouraging public speaking and debate among the members. Since the membership of the Engineering Society has increased to its present number the three sections into which it was divided proved to be too large to reach effectively the members, especially in view of the fact that members of widely different departments were grouped in the one sub-section of the Engineering Society. Consequently the need was felt for a change which would affiliate the various clubs under one central governing body, the Engineering Society, which is the medium through which the students may present their desires or grievances before the University authorities.

According to the amendments to the constitution of the Engineering Society, adopted at the meeting on Monday, March 9th, the executive will in future consist of 15 officers, as follows:—

1. President—a member of the IV year—elected by the entire electorate.

2. Five chairmen of the various clubs, each a member of the IV year, as follows:—

(a) Chairman of the Civil Club—elected by the undergraduate members of the department of Civil Engineers.

(b) Chairman of the Mining Club—elected by the undergraduate members in the departments of Mining and Metallurgical Engineering.

(c) Chairman of the Mechanical and Electrical Club—elected by the undergraduate members in the departments of Mechanical and Electrical Engineering.

(d) Chairman of the Architectural Club—elected by the undergraduate members in the department of Architecture.

(c) Chairman of the Chemical Club—elected by the undergraduate members in the departments of Analytical and Applied Chemistry and Chemical Engineering.

3. Vice-president—a member of the III year—elected by all the undergraduate members.

4. Corresponding secretary—a member of the III year—elected by all the undergraduate members.

5. Treasurer—a member of the III year—elected by all the undergraduate members.

6. Recording secretary—a member of the II year—elected by all the undergraduate members.

7. Curator—a member of the II year—elected by all the undergraduate members.

8. Four year representatives as at present—each elected by the members of his own year, and each to be president of his year.

Each chairman of a club shall preside over meetings of his club. He shall have power to call meetings of his club for the election of an executive or for the transaction of any other business pertaining to the interests of his club.

The elections on March 13th were conducted in accordance with the new constitution as amended at the meeting on March 9th. Owing to the pending proposed changes many candidates for some of the offices did not enter the field until March 10th, but once this matter had been cleared up there was an unusual number of contestants, as many as six candidates being nominated for one office. After a strenuous contest for the presidency, in which four candidates viz., R. D. Galbraith, E. D. Gray, L. T. Higgins, and R. E. Laidlaw were contestants, Mr. E. D. Gray was returned the winner.

The elections included all the features of the previous years, except the Brute Force Committee, which had to be dispensed with on account of the programme being conducted in the drafting room behind Convocation Hall, where the same conveniences for the "milling" process are not furnished as were enjoyed in the old gymnasium. However, the drafting room offers many advantages which offset the lack of the above mentioned convenience, and it is doubtful if a more enjoyable evening was ever spent on election night.

Tobacco, pipes and fruit were very much in evidence, the buffet service causing a good deal of turmoil and general mixing. The programme consisted of a hockey game in which roller-skates, brooms and a foot-ball constituted the implements of warfare, chariot races of various kinds, boxing, wrestling, blindfold boxing, fly-swatting, tangoing of all kinds, and many other impromptu innovations too numerous to mention and too new to name. The "Toikeoikestra" under the capable leadership of Mr. G. W. F. Johnston, furnished music throughout the evening, and so lent considerable toward the success of this, the last social function of the season.

When the smoke had cleared away and President Mechin was able to make himself heard above the din which reigned during

the whole evening, the executive was announced to have been elected as follows:—President, E. D. Gray; vice-president, F. T. McPherson; chairman of the Civil Club, C. R. McCort; chairman of the Mining Club, J. M. Muir; chairman of the Mechanical and Electrical Club, K. A. Jefferson; chairman of the Architectural Club, T. S. Graham; chairman of the Chemical Club, W. Uffelman; corresponding secretary, R. W. Downie; treasurer, H. A. Babcock; recording secretary, H. L. McClelland; curator, R. S. Bothwell; fourth year representative, W. R. McCaffery; third year representative, J. H. Eastwood; second year representative, A. B. Honeywell; first year representative, to be elected.

ENGINEERING ALUMNI ASSOCIATION

The Engineering Alumni Association held a meeting in the Chemistry and Mining Building on the evening of March 23rd. An attendance of over one hundred is announced. The meeting was addressed by David A. Molitor, C.E., designing engineer for the Toronto Harbor Commission. Mr. Molitor's lecture on the Panama Canal reviewed the subject from its earliest contemplation up to the nearly completed stage at which it is at the present time. The history of the early projects was briefly outlined and a comparison of the proposals which had occupied the minds of various countries prior to the selection of the present type was carefully made. The lecturer devoted the greater part of his address to a description of the engineering features of the canal. The excavation work for the selected lock-level type, the formation of Gatun Lake, dam and spillway, the types of various locks and dams at Pedro Miguel, Miraflores and Gatun, were lengthily dwelt upon and the emergency dams which Mr. Molitor himself designed for the protection of the canal and the preservation of the water level of Gatun Lake created much interest.

The lecture was illlustrated by over one hundred slides and was followed by an interesting discussion. Mr. Molitor's answers to the many questions submitted to him bringing forth some very instructive details of the design and execution of the work.

The president of the Toronto branch of the Association, Mr. E. W. Oliver, manager of construction, Mackenzie, Mann & Co., was unable to be present at the meeting owing to his being temporarily absent from the city because of indisposition. Mr. T. H. Hogg, assistant hydraulic engineer to the Hydro-Electric Power Commission of Ontario, occupied the chair in his absence.

Another meeting is being arranged for by the Association at an early date. It is expected that at about the middle of April Mr. J. L. Weller, chief engineer of the Welland Canal, will deliver a lecture on the design and construction of the various locks on the new Welland Ship Canal. Owing to the popularity of this enterprise at the present time the lecture will doubtless be well attended by the graduates, to whom notices of the exact date will be sent in a few days.

The annual meeting of the Toronto branch will be held towards the end of April.

THE KINEMATOGRAPH IN SCIENTIFIC RESEARCH

On another page of this issue our readers will find an interesting description by Professor Anderson, of the newly installed kinematograph, which will be a valuable addition to the facilities at the University for scientific research. The kinematograph was first used to illustrate a lecture by Mr. F. N. Speller, B.A. Sc., '93, before the Engineering Society of the University on February 5th, an extract of which will appear in an early issue of APPLIED SCIENCE. The value of this equipment will be made manifest, not only in addresses such as are given before the Engineering Society, but also in many of the studies which, according to the curriculum enter into a University training.

The very great importance of visualization in teaching is so universally recognized that projecting lanterns form a most important part of the equipment of every scientific institution in the country, and every lecturer who wishes to make his subject clear and attractive feels bound to provide plenty of pictorial illustration. However, it must be admitted that while the stationary picture forms an invaluable adjunct to a description of an object, be that what it may, that picture fails to convey any adequate idea of a process, of an event, of machinery in motion, of people in action, in short of life in general. The photograph exhibits all life and motion as instantly arrested—a sort of cold-storage representation, if one may use the expression.

With the kinematograph, however, all is different, and we see representations of events taking place, of processes being carried on, of machinery in motion and of people moving about as in actual life. Perhaps it is not too much to say that the kinematograph is as great an advance on the stationary lantern slide or photograph as the latter was on the laborious written descriptions that preceded the discovery of photography.

There is scarcely a branch of scientific work in which this method of illustration may not be used with the greatest advantage. In elementary education where the child learns most readily through observation, we may use motion pictures to teach history, geography, and nature study and to illustrate manual training and handicrafts of all sorts. In more advanced work, engineering in all its branches affords a fruitful field for this method of instruction. Methods of manufacture, mining operations, erection methods in construction work, and hundreds of other operations can easily be demonstrated to good advantage by this means. In the domain of medicine there is also abundant scope for the moving picture, whether we are dealing with objects of large size or minute organisms that are only visible through the microscope. In military operations or naval manoeuvres there is likewise an ample field of usefulness for this method. The naturalist will welcome the kinematograph as an unrivalled method of studying and illustrating the habits and motions of animals and the growth of plants. Many other possibilities will no doubt occur to the reader, but enough has been indicated to show the universality of the motion picture in educational work and it is not too much to predict that we shall soon see every technical school and university equipped with a paraphernalia for this work, as the University of Toronto has been equipped.

Clegg, B. D., '13. His home is at 295 Stewart St., Peterborough, Ont.

Clement, S. R. A., '05, was with the Hydro Electric Power Commission, but this is not his latest address.

Clement, W. A., '89, is city engineer of South Vancouver, B.C.

Cline, C. G., '09, is on the staff of the hydrographic survey, railway belt, Kamloops, B.C.

Clothier, G. A., '99, was, when last heard from, with the LeRoy Mining Co. as engineer at Rossland, B.C.

Coates, P. C., '04, was at Revelstoke, B.C., according to our last information.

Cockburn, J. R., '01, is assistant professor of drawing in the Faculty of Applied Science and Engineering, University of Toronto.

Cockburn, L. S., '10, is in the technical division, topographical surveys branch, Dept. of Interior, Ottawa.

Cockburn, L. S., '10, is in the Topographical Surveys Branch, Dept of Interior, Ottawa.

Code, A. G., '10, is switchboard engineer for the Canadian Westinghouse Co., Hamilton.

Code, S. B., '04, is town engineer of Smith's Falls, Ont. He has a private practice as civil engineer and surveyor.

Code, T. F., '04, deceased October 29th, 1906.

Cole, C. R., '10, his home is in Woodstock, Ont.; we do not know what he is doing at present.

Cole, D. B., '11, is smelter maintenance engineer for the Canadian Copper Co., at Copper Cliff, Ont.

Cole, '08, deceased December 31st, 1909.

Coleman, J. H., '13, is illuminating engineer for Toronto Electric Light Co., Toronto. His address is 17 Farnham Ave.

Coleman, R. M., '10, is assistant sales manager for the Toronto Electric Light Co., Toronto, Ont.

Colhoun, G. A., '06, is draughtsman for the Hamilton Bridge Works Co., Hamilton, Ont.

Collett, W. C., '08, is manager of Collett's Carriage Works, Toronto, Ont.

Collinson, J. G., '09, has St. Thomas, Ont., as his home address.

Collinson, W. G., '09, is chemist for the Carborundum Co., of Niagara Falls, N.Y.

Colquhoun, G. A., '10, is with the Topographical Surveys Branch, Department of the Interior, Ottawa.

Coltham, G. W., '09, is carrying on an engineering and surveying practice at Aurora, Ont.

Conlon, F. T., '02, deceased, July 10th, 1912.

Connell, C. B. B., '07, has no address with us at present.

Connor, A. W., '95, is a member of the engineering firm of Bowman & Connor (H. J. Bowman, '85) with offices in Toronto and Berlin, Ont.

Connor, H. V., '02, is with the Canadian Westinghouse Co., Hamilton, Ont.

Cooch, H. A., '09, is sales engineer for the Canadian Westinghouse Co., with headquarters in Toronto.

Cook, A. S., '11, is connected with the Geo. R. Cook Co., contracting engineers, Ford Building, Detroit. He is at present in Alpena, Mich. superintending the contract for building the foundations for a large limestone crushing plant.

Cook, G. M., '13, is designing engineer for the Trussed Concrete Steel Co., Walkerville, Ont.

Cook, W. A. M., '06, is structural engineer in the offices of the city architect, Toronto.

Coombs, J. A., '13, is at Arnprior, Ont.

Coon, B. R., '13, is a member of the firm S. B. Coon & Son, architects, Temple Building, Toronto.

Cooper, C., '99, is with the Keokuk & Hamilton Water Power Co., Keokuk, Ia.

Corman, W E., '09, is chief draughtsman for C. H. & P. H. Mitchell, Traders Bank Building, Toronto.

Cornell, C. W., '11, is a member of the firm, Jones, Cornell Construction Co., Limited, engineers and contractors, New Westminster, B.C.

Corrigan, G. D., '90, deceased May 6th, 1907.

Corrigan, T. E., '05, is electrical contractor, Begbie St., New Westminster, B.C.

Cory, R. Y., '08, is in charge of the bond department of Baillie, Croft & Wood, Toronto.

Coulter, G. P., '07, we do not know his address.

Coulson, C. L., '03. His home is in Welland, Ont. We do not know the nature of his professional work.

Cousins, E. L., '06, is harbor engineer for the city of Toronto.

Coulthard, R. W., '99, is general manager of the West Canadian Collieries, Limited, at Blairmore, Alta.

Coumans, O. H., '11, is Provincial Drainage Engineer, Regina, for the Saskatchewan Government.

Cowan, W. A. We have not his address on file.

Cowper, G. C., '07. His home is in Welland, Ont. He is engaged on D. L.S. Topographical Surveys.

Coyne, H., '08, is chief draughtsman for Thomas & Thomas, Racine, Wis.

Craig, J. A., '99, is engaged in civil engineering and surveying at Prince Albert, Sask.

Craig, J. H., '10, is a member of the architectural firm of Craig & Madill, Manning Chambers, Toronto.

Craig, S. E., '04. We do not know his address.

Creighton, A. G., '06, is a member of the firm of Creighton & Strothers, architects and structural engineers, Prince Albert, Sask.

Crerar, S. R., '04, is lecturer in surveying, Faculty of Applied Science and Engineering, University of Toronto.

Crosby, N. L. R., '05, is contracting engineer with Toronto Structural Steel Co., Toronto, Ont.

Crosby, T. H., '09, is sales engineer with the Canadian Westinghouse Co., in the Vancouver office.

Crouch, M. E., '11, is assistant to H. J. Beatty, engineer and surveyor, Pembroke, Ont.

Cruthers, W. M., '11, is in the engineering department of the Canadian General Electric Co., at the Peterborough plant.

Culbert, J. V., '07, is with the Buffalo Mines, Cobalt, Ont.

Culbert, M. T., '02, deceased March 14th, 1911.

Cumming, J. D., '08, is at Copper Cliff, Ont., with the Canadian Copper Co.

Cumming, R., '02, is a member of the contracting firm of Miller, Cumming & Robertson, Toronto.

Cunerty, T. J., '11, is with the Westinghouse Electric and Manufacturing Co., East Pittsburg, in the publicity dept.

Cunningham, C. H., '11, is designing engineer for Thor Iron Works, Toronto, of which firm he is a director.

Cunningham, R. H., '09, is at Windsor, Ont. He is sales engineer for the Hoskin Manufacturing Co., Detroit.

Currie, W. M., '04, is a member of the staff of the Canada Steel Co. Hamilton.

Curtis, W. T., '13, is with the Buffalo Mines, Cobalt, Ont.

Curzon, J. H., '11, is Fellow in surveying at University of Toronto.

D

Dahl, A. D., '08, has Midland, Mich., for his address. He is research chemist for the Dow Chemical Co.

Dallyn, F. A., '09, is with the Ontario Board of Health as consulting expert, in charge of the experimental station at Toronto.

D'Alton, F. K., '11, is with the Canadian General Electric Co., Peterboro', Ont.

Daniels, W. N., '06, is in Philadelphia, Pa., in the employ of the John R. Wiggins Co.

Danks, F. A., '08, whose home is in Toronto, has no business address in our directory.

Danks, C. N., '09, is with the Jenckes Machine Co., Sherbrooke, Que., as engineer.

Dann, E. M., '09, is assistant engineer on hydrographic survey work in B. C. for the water power branch, Department of the Interior.

Darling, E. H., '98, is a member of the firm, McPhie, Kelly & Darling, Consulting engineers, Bank of Hamilton Building, Hamilton, Ont.

Darroch, J., '08, has no address with us at present. When last heard from him he was with the Autoparts Mfg. Co., Detroit, Mich., as draftsman.

Dates, A. J., '13, is draftsman with Harkness & Oxley, consulting engineers, Toronto.

Davidson, H. D., '13. We do not know his present address.

Davis, A. I., '09, is with the Canada Foundry Co., Toronto.

Davis, J., '09, is sales engineer for the Canada Foundry Co. in connection with the Ottawa office.

Davis, H. W., '09, resides in Kingston, Ont., where he is in charge of the power department of the Davis Tanneries, Limited.

Davis, H. C., '09. We do not know his present address.

Davis, R. S., '07, is manager of the Calgary office of the Canadian Westinghouse Co.

Davis, W. B., '11, is at Maple Creek, Sask., and is engaged in land surveying.

Davison, J. E., '00, is in the engineering department of the Canadian Northern Ry. Co. at Fort William, Ont

Davison, A. E., '03, is with the Hydro Electric Power Commission, as engineer, with Toronto as headquarters.

Dawson, I. H., '09, is resident engineer for the T. C. R., at Hearst, Ont. St. Catharines is his permanent address.

Deacon, T. R., '91, is president and general manager of the Manitoba Bridge and Iron Works. He is Mayor of Winnipeg, Man.

Dean, C. D., '10, has Sarnia, Ont., for his home address. We do not know his business address.

Death, N. P. F., '06, is a member of the firm of Death & Watson, electrical engineers and contractors, Toronto.

DeCew, J. A., '96, is in Montreal, Que., where he has a consulting practice in chemical engineering.

DeGuerre, F. C., '11, is in the engineering department of the British Columbia Electric Co., at Vancouver, B.C.

Deitch, E. L., '13, is inspector with the Ontario Hydro-Electric Power Commission at Hamilton, Ont.

Delahaye, W. H., '09, is in the Patent Office, Dept. of Agriculture, Ottawa.

De Laporte, A.V. '10, is chemist with the Provincial Board of Health, Toronto.

Depew, H. H., '04, is in Edmonton, Alta. We do not know his business address.

Derham, W. P., '09. He has no business address on our fyles.

Diamond, R. W., '13, is with the Anaconda Copper Mining Co., Anaconda, Montana.

Dickson, G. W., '00, is with the Laurentide Co., Limited, Grand Mere, Quebec, paper manufacturers, as superintendent of the ground wood department.

Dickenson, E. D., '00, is with the General Electric Co., at Schenectady, N. Y.

Dill, C. W., '91, is managing director of the National Paving and Contracting Co., Winnipeg, Man.

Dixon, H. A., '00, is at Jasper, Alta., as district engineer for Mackenzie, Mann & Co., on the C. N. P. Ry.

Dobbin, R. L., '10, is inspecting engineer with the Dominion Engineering and Inspection Co., on the Dominion Bank Building, Toronto.

Dobson, W. P.. '10, is research fellow for the University of Toronto Engineering Alumni Association.

Dobie, J. S., '95, resides at Thessalon, Ont. He is engaged in O. L. S. and D. L. S. work.

Dodds, W. A., '09, is chemical engineer for the Penman Littlehales Chemical Co., of Syracuse, N. Y.

Doorly, H. C., '08. Deceased, February, 1913.

Douglas, R. H., '08, has no address with us at present.

Douglas, W. E., '02, is secretary-treasurer of the McKnight Construction Co., Toronto.

Dowling, F., '05, is with the Manitoba Bridge and Iron Works, Winnipeg.

Downing, F. H., '11, whose home is at Lucan, Ont., is with the Manitoba Bridge and Iron Works, Winnipeg.

Duff, A. R., '09, is chemist for the Dunlop Tire and Rubber Goods Co., Toronto, in the rubber department.

Duff, J. A., '90 (deceased), March 13th, 1902.

Duff, M. O., '09, His last address with us is 4 Hughson St. S., Hamilton, Ont.

Duff, W. A., '01, is engineer for bridges for the Intercolonial Railway Co., Moncton, N.B.

Duggan, G. H., '83, is vice-president and chief engineer of the Dominion Bridge Co., and chief engineer of the St. Lawrence Bridge Co., Montreal.

Dunbar, W. B., '11, whose home is in Dunbarton, Ont., is in the construction department, Toronto Power Co., Toronto.

Duncan, J. M., '10. His last address with us is Greenwood, Ont.

Duncan, W. G., '13. His address is not on our fyles.

Dundass, C. S., '06, is at Lachine, Que., with the Dominion Bridge Co., as draftsman.

Dunlop, R. J., '02, is a member of the National Refining Co., dealers in dental supplies ,Toronto.

Dunn, T. H., '93, is reclamation engineer, Water Power Branch, Dept. of Interior, Ottawa.

Duthie, L. J., '09, is with the Porcupine Crown Mine, Timmins, Ont.

Dyer, F. C., '08, is lecturer in mining engineering, University of Toronto.

E

Eagleson, F. M., '08, is engaged in civil engineering, surveying, and municipal work at Winchester, Ont.

Eason, D. E., '01, is division engineer on the construction of the Trent

Valley Canal, at Peterborough, Ont.

Eckert, C. H., '11, is with the Standard Chemical Co., at Longford, Ont., as chemist.

Eadie, L., '10, has 90 Laughton Ave,, West Toronto, as his address.

Edwards, W. M., '02, is a member of the firm of Duff & Edwards, engineers and surveyors, Lethbridge, Alta.

Edwards, C., '08, is with the Sewer Section, Department of Works, City of Toronto.

Elder, A. J., '04, is with the Department of the Interior, at Ottawa, in the Topographical Surveys Branch.

Elliott, C. F., '11, is enrolled at Osgoode Hall, supplementing his engineering course with one in law.

Elliott, G. R., '11, is with the Hydrographic Surveys Branch, Department of the Interior, at Calgary.

Elliott, H. P., '96, is a consulting engineer with offices in London and Toronto.

Elliott, J. A., '11, is engaged as chemist with the Castner Electrolytic Alkali Co., of Niagara Falls, N.Y.

Elliott, J. C., '99, whose home is at Kelso, Ont., has no other address with us.

Elwell, W., '02, deceased Sept. 3rd, '09.

Emery, V. H., '10, is Mine Superintendent, Hollinger Mines, Timmins, Ont.

Empey, J. M., '02, is with the Department of Public Works, Calgary, as district engineer and surveyor.

English, A. B., '90 (deceased).

Evans, J. H., '11, has no address with us.

Evans, S. D., '07, has no other address than his home at Leamington, Ont., upon our lists.

Evans, S. L., '08, has Corinth, Ont., for his address. He is engaged in land surveying.

Evans, W. J., '10, is in the employ of the Canadian Westinghouse Co. at Hamilton, Ont.

Ewart, J. A., '94, resides in Ottawa, Ont., where he has an architectural practice.

Ewart, F. R., '07, is in Toronto, with the Toronto Hydro Electric System.

Ewing, E. O., '08, is in Toronto. He is engaged in surveying and structural engineering.

F

Fairburn, J. M. R., '93, is with the Canadian Pacific Railway as assistant engineer, located in Montreal.

Fairchild, C. C., '92, has a practice as consulting engineer and surveyor, Teglar Block, Edmonton, Alta.

Fairlie, H. W., '10, is in the employ of the Northern Electric & Mfg. Co., in their Winnipeg office.

Falconer, F. S., '09, is with the topographical survey branch, Department of the Interior, Ottawa.

Fargey, T. A., '09, is electrical engineer for the Scott Bros. Electric Co., Detroit, Mich.

Farrell, K. A., '11, is assistant engineer with Speight & Van Nostrand, Toronto.

Farquharson, W., '11, is with the Geo. R. Cook Co., Contracting Engineers of Detroit, at Alpena, Michigan.

Farelly, T. J., '11. We have not his present address.

Fear, S. L., '06, is in charge of the gas engine department of the Canada Foundry Co., Toronto.

Fensom, C. J., '03, is works engineer, Otis-Fensom Elevator, Co., Hamilton.

Ferguson, C. R., '10, is draftsman with the Dominion Bridge Co., Toronto.

Ferguson, G. H., '05, is assistant engineer to the Commission of Conservation, Canada.

Ferguson, J. B., '09, is in Winnipeg with the C. N. Ry. in the Engineering Department, Maintenance of Way.

Ferguson, J. W., '10, is with McGregor & McIntyre, structural contractors, Toronto.

Ferguson, A. T., '09, is a member of the firm of G. T. Fergusson & Co. stock brokers, Toronto.

Fiddes, F. R., '13, is at Detroit, Mich., with the H. W. Johns-Manville Co., in the capacity of architectural engineer, at their Detroit branch.

Fierheller, H. S., '05, deceased, June, 1910.

Fingland, W., '93, is engaged in architecture. His office is in Winnipeg, Man.

Fisken, J. B. K., '10, is with Darling & Pearson, acrhitects, Toronto.

Flanagan, O. L., '08, is resident engineer on the Prince Albert hydro-electric development, at Prince Albert, Sask, for C. H. & P. H. Mitchell, Toronto.

Fleck, J. G., '04, is a member of the firm of Fleck Bros., Vancouver, B.C.

Fleming, D. H., '13, is leveller in the Sewer's Dept., City Hall, Toronto.

Fleming, G. R. S., '07, is with Atwell Fleming Printing Co., as superintendent.